# Indoor Air Contaminant Monitoring & Removal

## Integrated Energy Systems (IES) Peer Review Meeting
## May 2, 2002


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# This Project Consists of 3 Related Tasks

All three tasks are concerned with the behavior of organic contaminants in indoor environments:

1. Rapid Laboratory-Scale Testing of Contaminant Removal Performance of Desiccant Materials
2. Contaminant Removal Performance Testing of Full-Scale TAT components
3. Chemical Sensors for Real-time Indoor Air Quality Monitoring

# Indoor Air Contaminant Monitoring & Removal

1. **Rapid Laboratory-Scale Testing of Contaminant Removal Performance of Desiccant Materials**
2. Contaminant Removal Performance Testing of Full-Scale TAT components
3. Chemical Sensors for Real-time Indoor Air Quality Monitoring

# Rapid Laboratory-Scale Testing of Contaminant Removal Performance of Desiccant Materials

Conventional Test methods were designed for Industrial Gas Cleaning Applications (e.g. carbon adsorption, zeolite concentration)

Industrial contaminants are typically present at 100+ part-per-million (ppm), while Indoor Environments typically have parts-per-billion (ppb) levels of organic contaminants

Application of conventional tests to ppb-level contaminants =excessively long tests (100's hours)

We have developed laboratory techniques to perform these tests up to 50 times faster than conventional techniques

Manuscript in preparation summarizing this work

# Indoor Air Contaminant Monitoring & Removal

1. Rapid Laboratory-Scale Testing of Contaminant Removal Performance of Desiccant Materials

2. **Contaminant Removal Performance Testing of Full-Scale TAT components**

3. Chemical Sensors for Real-time Indoor Air Quality Monitoring

# 2 Contaminant Removal Performance Testing of Full-Scale TAT components

- New Task This Year
- Complements existing NREL expertise in thermal performance monitoring of TAT components
- Leveraging separate NREL Investments in state-of-the art GC/MS (Agilent 6890/5973) and Thermal Desorption Equipment (Perkin-Elmer ATD-400)
- Testing should commence this summer

# Indoor Air Contaminant Monitoring & Removal

1. Rapid Laboratory-Scale Testing of Contaminant Removal Performance of Desiccant Materials
2. Contaminant Removal Performance Testing of Full-Scale TAT components
3. **Chemical Sensors for Real-time Indoor Air Quality Monitoring**

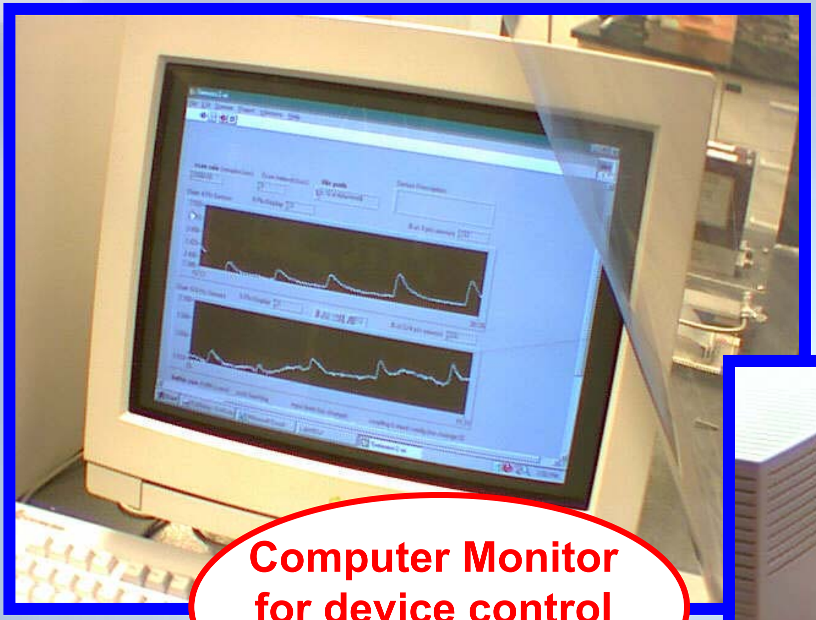
# Background and Motivation

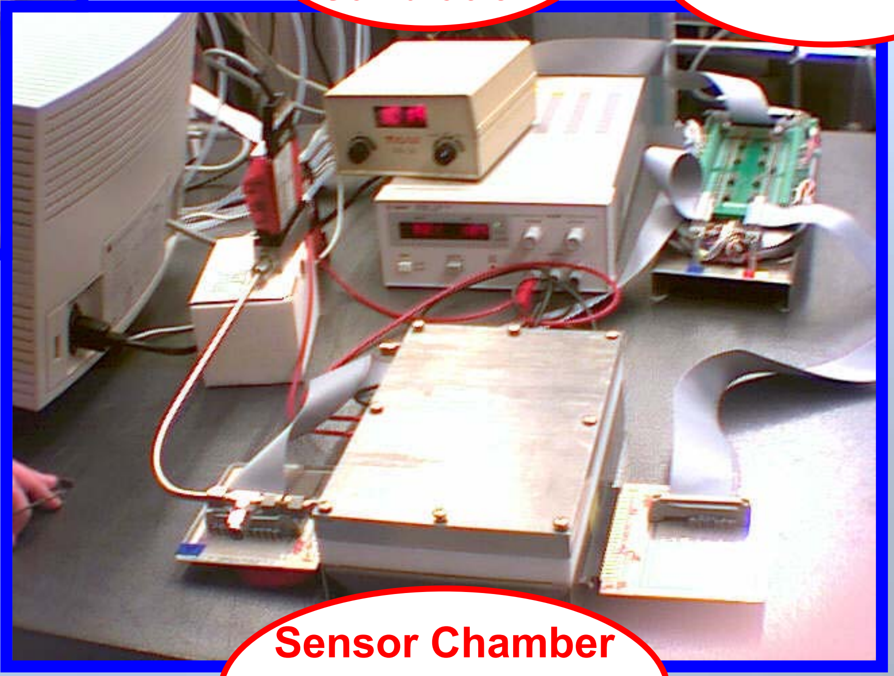
- Real-time monitoring is important for demand-controlled ventilation
- This is difficult because ambient concentrations are low (generally less than ppm)
- Analytical devices with these sensitivities are expensive (e.g. >$25k- GC/MS, FTIR,...)
- Operating cost is high (know-how and maintenance)

## Our approach:

- Use low cost commercially-available sensors
- Exploit sophisticated signal processing to enhance sensor selectivity and sensitivity
- Package a "smart" unit

# Laboratory Development System



# FY01 Accomplishments:

- ✓ Design and construct prototype sensor system
- ✓ Design and construct data acquisition system
- ✓ Test overall system
- ✓ Develop a test protocol and data analysis strategy
- ✓ Characterize sensor geometry features
- Characterize sensor signals
- Demonstrate qualitative distinction among organic compounds
- ✓ Refine system geometry, modify sensor operating conditions

Commercial sensors are good enough!

Signal processing is powerful!

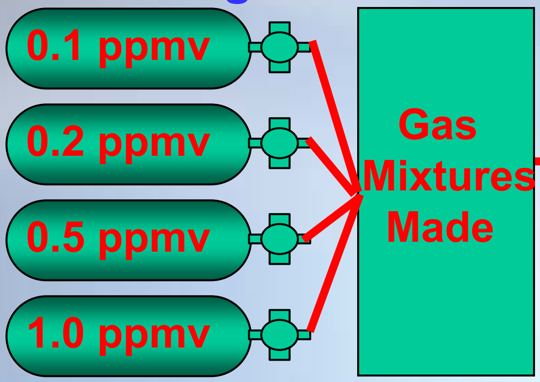
# Tasks Completed Since Last June:

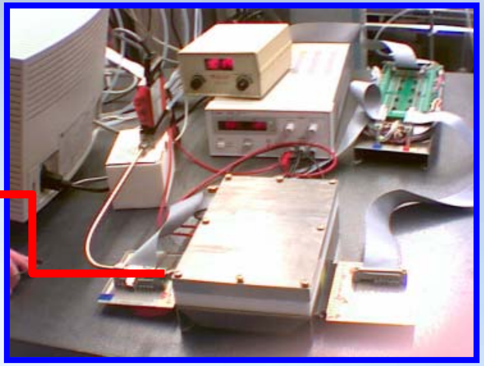
- ✓ Examined the effect of temperature
- ✓ Added temperature sensors to the system
- ✓ Added relative humidity sensor to the system
- ✓ Constructed a gas manifold for binary and ternary mixture calibrations
- ✓ Demonstrated the generality of the system calibration:

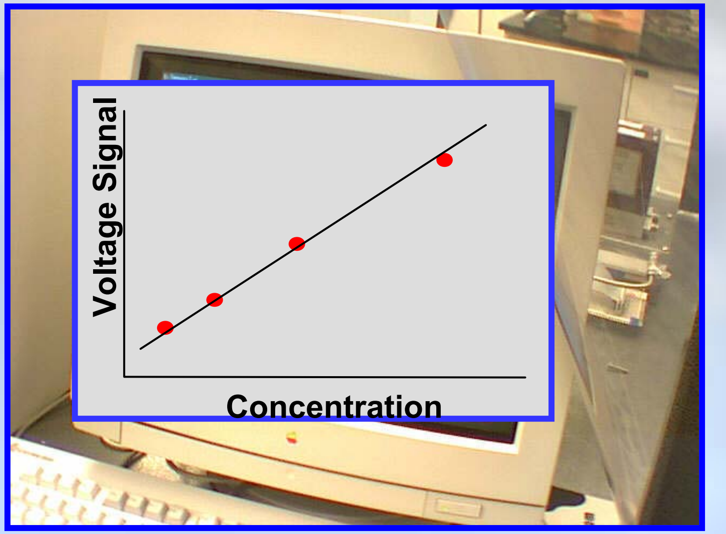
  toluene, benzene, isopropyl alcohol, acetone,
  ethanol, ethylbenzene, o-xylene
- ✓ Demonstrated binary and ternary mixture quantitative calibration
- ✓ Constructed a portable unit for demonstration and field tests

# Calibration

Calibration gases

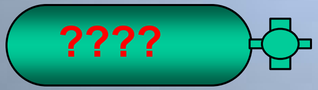


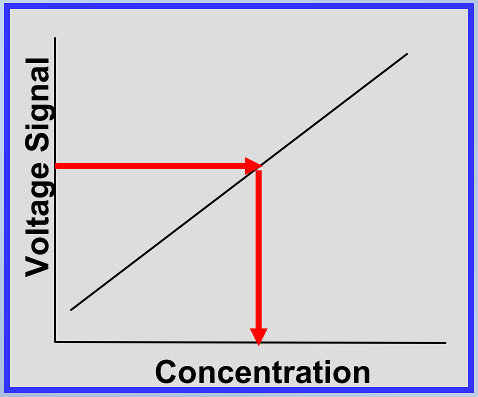






$$Y_{(signal\ V)} = b_0 + m_{tol1} X_{tol}$$

## Measurement (Inverse calibration)



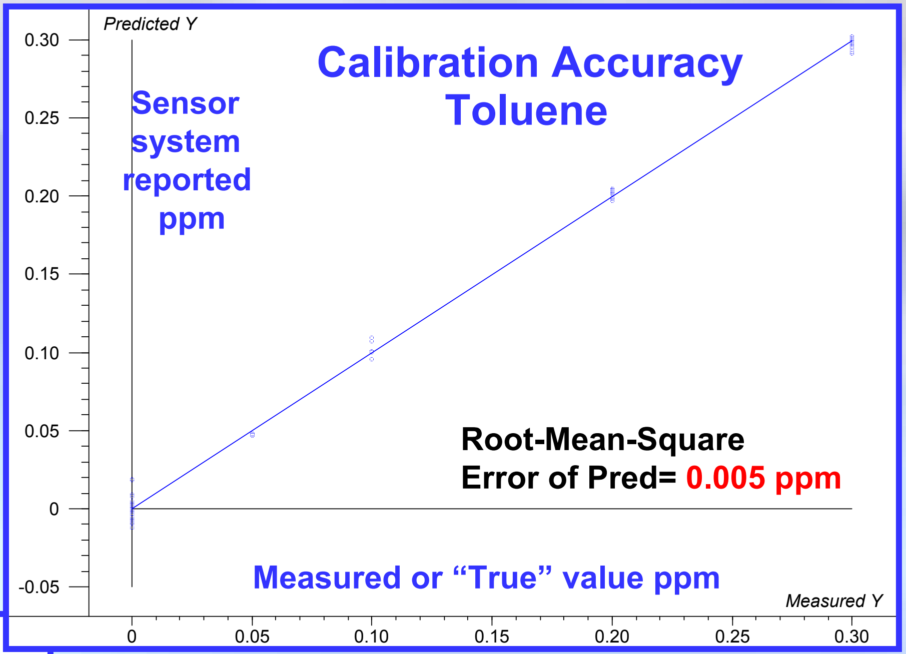



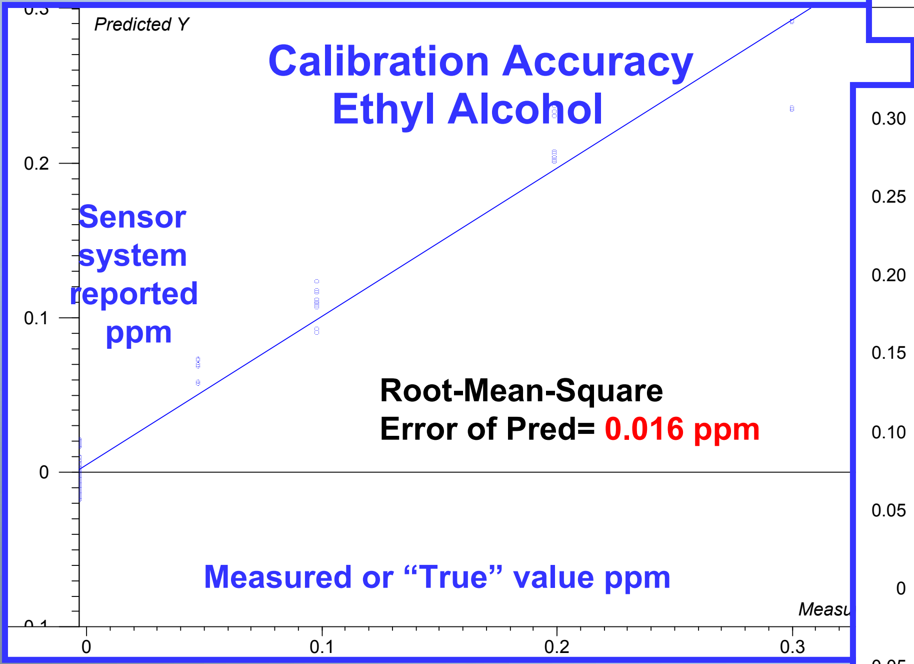

$$X_{tol} = \frac{Y_{signal\ V} - b_0}{m_{tol1}}$$

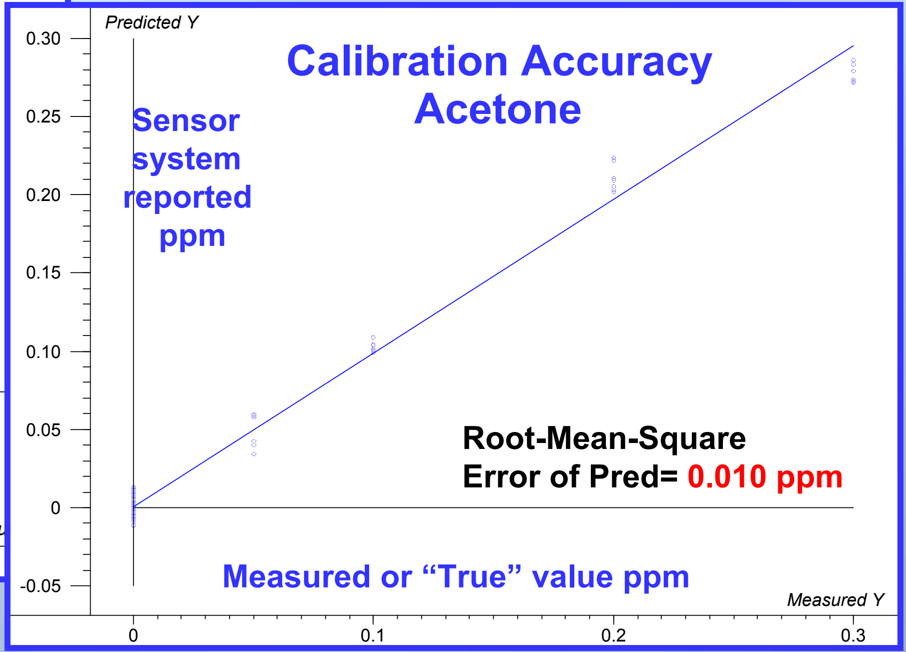
3

# Calibration accuracy in ternary mixtures

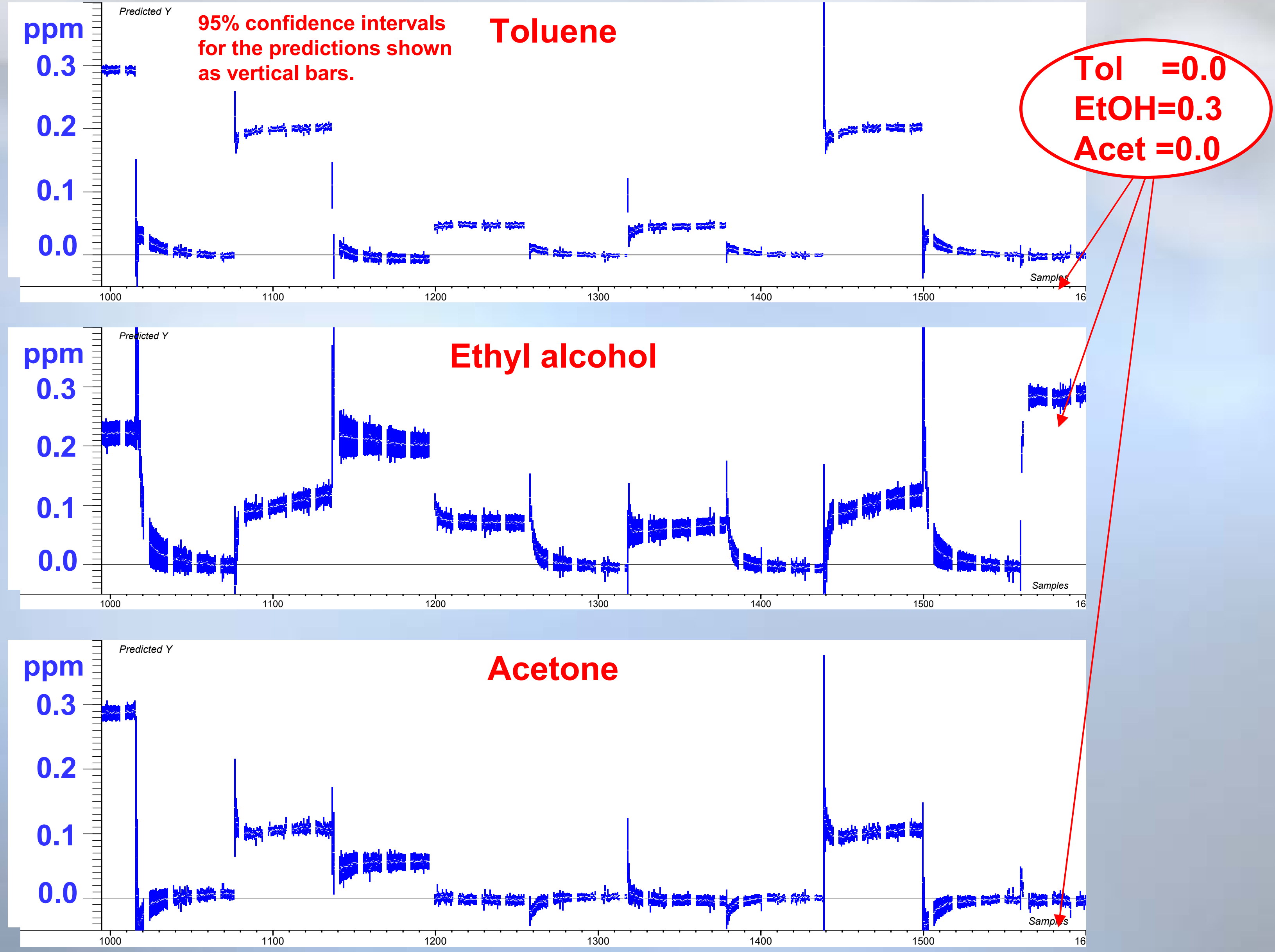
**toluene, benzene, isopropyl alcohol, acetone, ethanol, ethylbenzene, o-xylene**



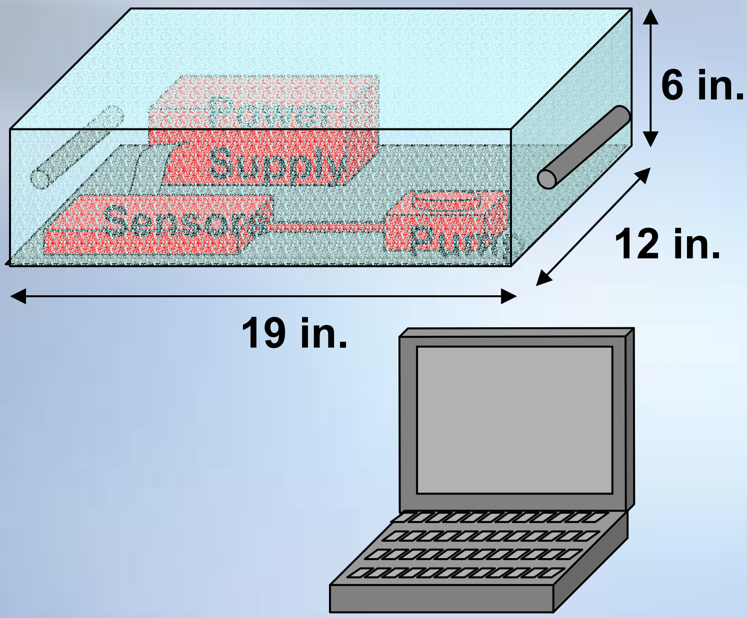



# Prediction of "apparent analyte" during a calibration experiment




Time (one measurement per 15 sec. shown)

# 3 Portable Unit for Field Testing and Demonstration

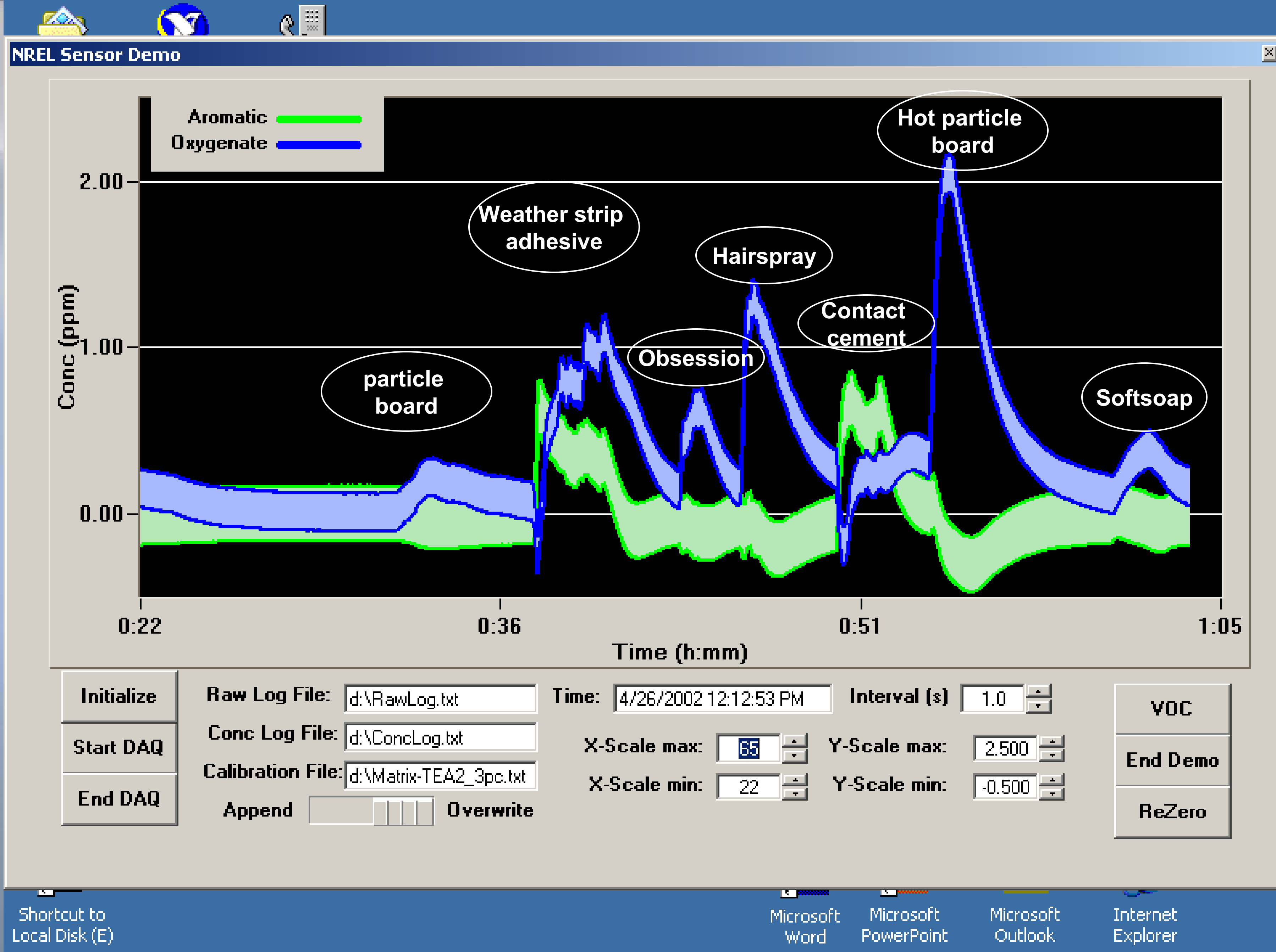



**Test objectives:**

1: to develop a self-contained control system (laptop)

2: to show that the system operates in different locations

3: to test whether calibration transfer (lab to unit) can be accomplished


NREL Sensor Demo
Aromatic
Oxygenate
Hot particle board
Weather strip adhesive
Hairspray
Contact cement
Obsession
particle board
Softsoap
2.00
1.00
0.00
Conc (ppm)
0:22
0:36
0:51
1:05
Time (h:mm)
Initialize
Start DAQ
End DAQ
Raw Log File:
d:\RawLog.txt
Conc Log File:
d:\ConcLog.txt
Calibration File:
d:\Matrix-TEA2_3pc.txt
Append
Overwrite
Time:
4/26/2002 12:12:53 PM
Interval (s)
1.0
X-Scale max:
65
X-Scale min:
22
Y-Scale max:
2.500
Y-Scale min:
-0.500
VOC
End Demo
ReZero
Shortcut to Local Disk (E)
Microsoft Word
Microsoft PowerPoint
Microsoft Outlook
Internet Explorer

# Vision of a Commercial Unit

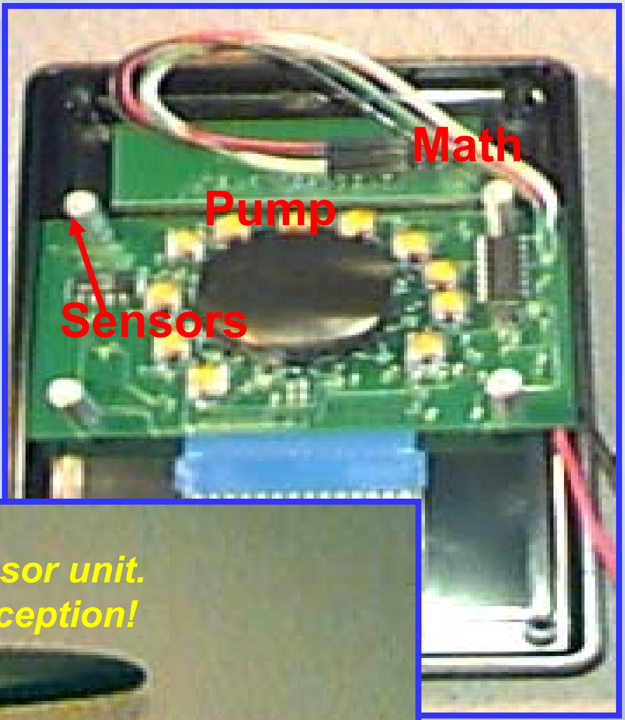
What will it contain?

How will it function?

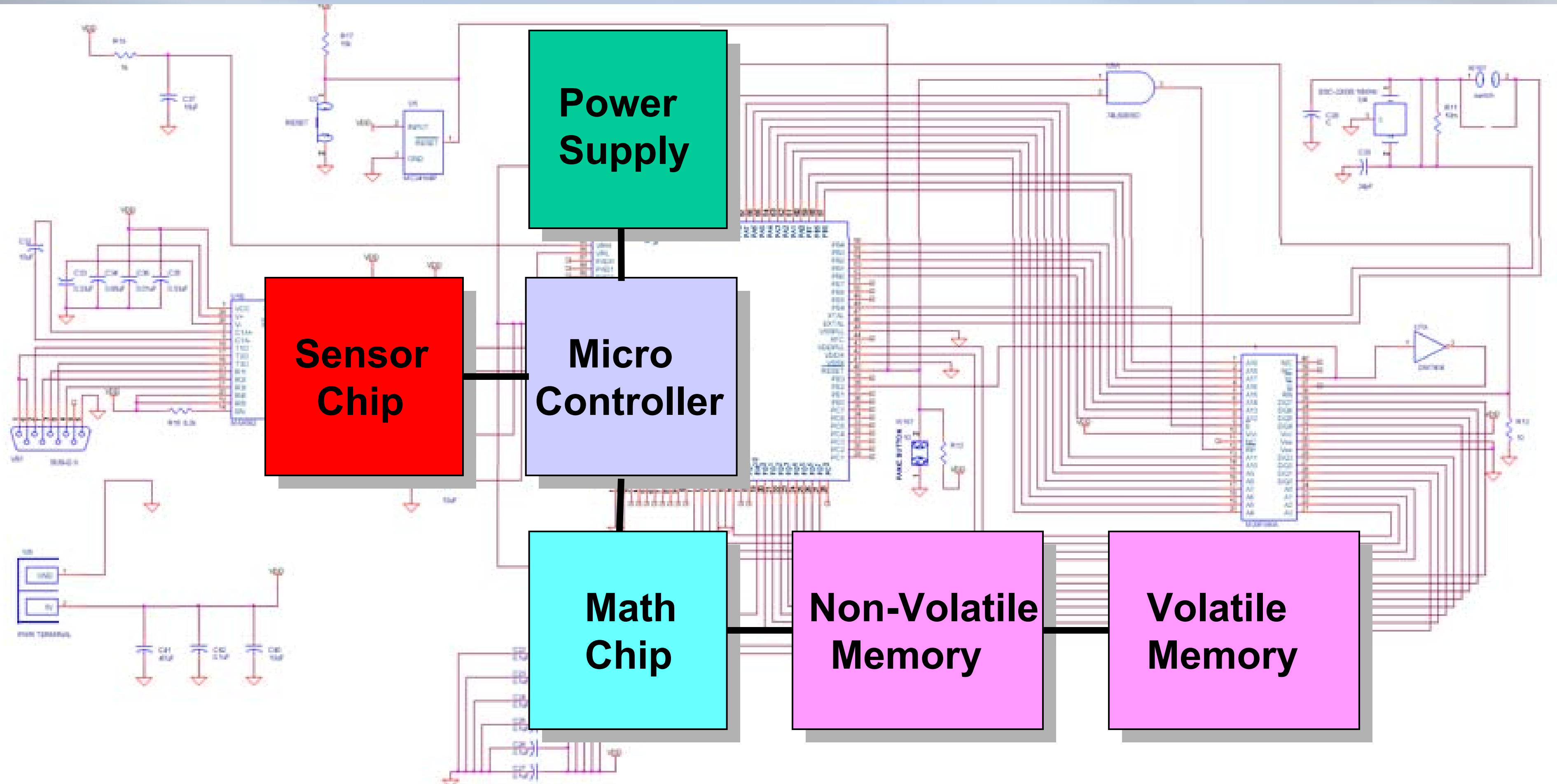
Who might use this?

3

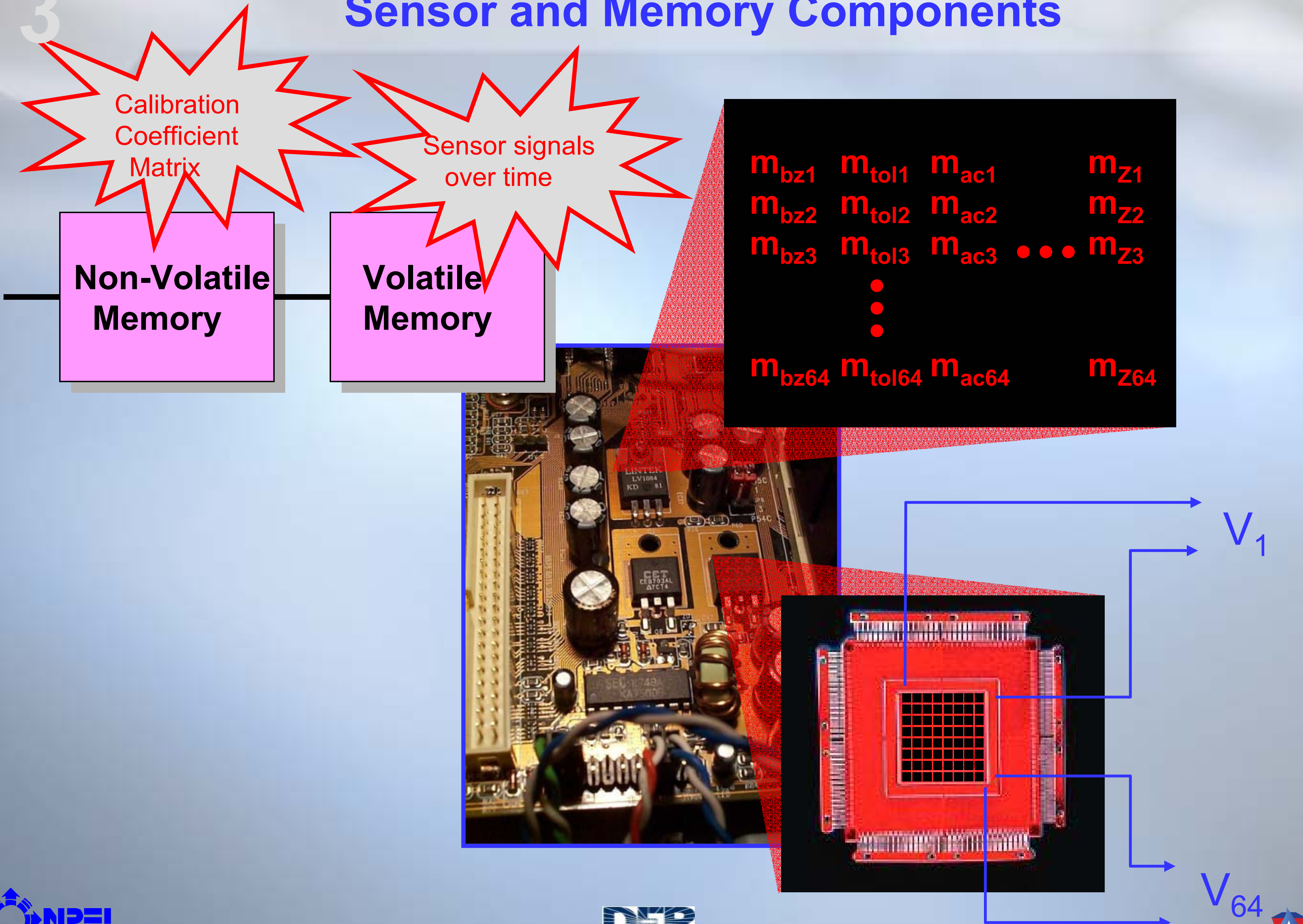
# Commercial unit: small, "smart", self-contained unit

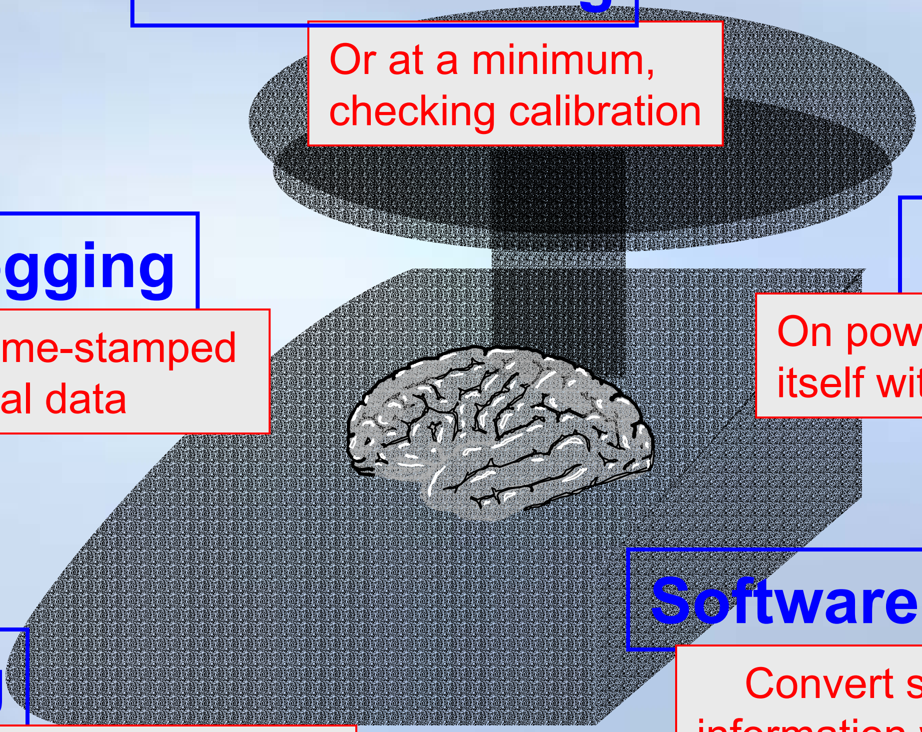

# Electronic Components of Final unit



# Sensor and Memory Components



# Features of a “smart” commercial unit



**Self-calibrating**

Or at a minimum, checking calibration

**Data-logging**

Store time-stamped historical data

**Self-identifying**

On power-up it should integrate itself with the larger system

**Software-reporting**

Convert sensor data to useful information without human intervention

**Self-testing**

Perform operational readiness tests, provide diagnostics.

**Wireless network**

Portability and low installation cost

# Next Steps

- Examine transient vs. steady state responses (validity of calibrations)
- Calibration transfer… Technology Hurdle
- Secure intellectual property
- Miniaturization of the solid state sensor Technology Hurdle